**Chapter 22 Section 3 Earth’s Moon**

**Key Concepts**

* [What processes create surface features on the moon?](javascript:openCrossRef('../ch22/ch22_s3_1.html%23lnk631.3'))
* [How did the moon form?](javascript:openCrossRef('../ch22/ch22_s3_2.html%23lnk633.2'))

**Vocabulary**

* [rille](javascript:openCrossRef('../ch22/ch22_s3_1.html%23lnk632.4'))
* [lunar regolith](javascript:openCrossRef('../ch22/ch22_s3_1.html%23lnk632.5'))
* [crater](javascript:openCrossRef('../ch22/ch22_s3_1.html%23lnk631.3'))
* [ray](javascript:openCrossRef('../ch22/ch22_s3_1.html%23lnk632.1'))
* [mare](javascript:openCrossRef('../ch22/ch22_s3_1.html%23lnk632.3'))

Earth now has hundreds of satellites. Only one natural satellite, the moon, accompanies us on our annual journey around the sun. Other planets have moons. But our planet-satellite system is unusual in the solar system, because Earth’s moon is unusually large compared to its parent planet. The diameter of the moon is 3475 kilometers, about one-fourth of Earth’s 12,756 kilometers.

**Figure 18** *This is what the moon’s surface looks like from Earth when viewed through a telescope.*

Much of what we know about the moon, shown in Figure 18, comes from data gathered by the *Apollo* moon missions. Six *Apollo* spacecraft landed on the moon between 1969 and 1972. Uncrewed spacecraft such as the *Lunar Prospector* have also explored the moon’s surface. From calculation of the moon’s mass, we know that its density is 3.3 times that of water. This density is comparable to that of mantle rocks on Earth. But it is considerably less than Earth’s average density, which is 5.5 times that of water. Geologists have suggested that this difference can be accounted for if the moon’s iron core is small. The gravitational attraction at the lunar surface is one-sixth of that experienced on Earth’s surface. (A 150-pound person on Earth weighs only 25 pounds on the moon). This difference allows an astronaut to carry a heavy life-support system easily. An astronaut on the moon could jump six times higher than on Earth.

**The Lunar Surface**

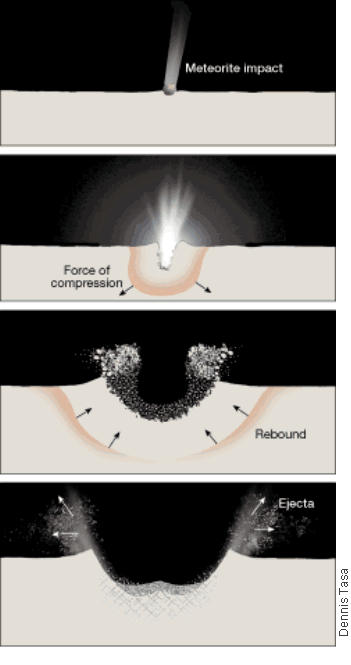
When Galileo first pointed his telescope toward the moon, he saw two different types of landscape—dark lowlands and bright highlands. Because the dark regions resembled seas on Earth, they were later named maria, which comes from the Latin word for *sea*. Today we know that the moon has no atmosphere or water. Therefore, the moon doesn’t have the weathering and erosion that continually change Earth’s surface. Also, tectonic forces aren’t active on the moon, therefore volcanic eruptions no longer occur. However, because the moon is unprotected by an atmosphere, a different kind of erosion occurs. Tiny particles from space continually bombard its surface and gradually smooth out the landscape. Moon rocks become slightly rounded on top after a long time at the lunar surface. Even so, it is unlikely that the moon has changed very much in the last 3 billion years, except for a few craters.

**Craters**

The most obvious features of the lunar surface are [**craters**](javascript:openGlossaryWnd('e_ga_06_crater_1a')), which are round depressions in the surface of the moon. There are many craters on the moon. The moon even has craters within craters! The larger craters are about 250 kilometers in diameter, about the width of Indiana. **Most craters were produced by the impact of rapidly moving debris.**

By contrast, Earth has only about a dozen easily recognized impact craters. Friction with Earth’s atmosphere burns up small debris before it reaches the ground. Evidence for most of the craters that formed in Earth’s history has been destroyed by erosion or tectonic processes.

The formation of an impact crater is modeled in Figure 19. Upon impact, the colliding object compresses the material it strikes. This process is similar to the splash that occurs when a rock is dropped into water. A central peak forms after the impact.

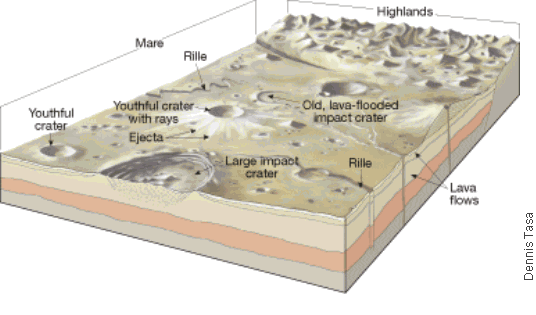
**Figure 19** *The energy of the rapidly moving meteoroid is transformed into heat energy. Rock compresses, then quickly rebounds. The rebounding rock causes debris to be ejected from the crater.*

Most of the ejected material lands near the crater, building a rim around it. The heat generated by the impact is enough to melt rock. Astronauts have brought back samples of glass and rock formed when fragments and dust were welded together by the impact.

A meteoroid only 3 meters in diameter can blast out a 150-meterwide crater. A few of the large craters, such as those named Kepler and Copernicus, formed from the impact of bodies 1 kilometer or more in diameter. These two large craters are thought to be relatively young because of the bright [**rays**](javascript:openGlossaryWnd('e_ga_06_ray')), or splash marks that radiate outward for hundreds of kilometers.

**Highlands**

Most of the lunar surface is made up of densely pitted, light-colored areas known as highlands. In fact, highlands cover the surface of the far side of the moon. The same side of the moon always faces Earth. Within the highland regions are mountain ranges. The highest lunar peaks reach elevations of almost 8 kilometers. This is only 1 kilometer lower than Mount Everest. Figure 20 shows highlands and other features of the moon.



**Figure 20** *Major topographic features on the moon’s surface include craters, maria, and highlands.* ***Identifying*** *Where are rilles located?*

**Maria**

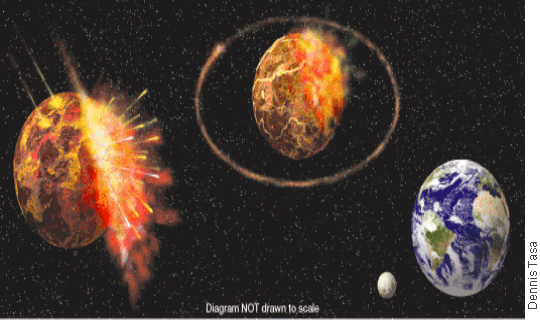
The dark, relatively smooth area on the moon’s surface is called a [**mare**](javascript:openGlossaryWnd('e_ga_06_mare')) (plural: maria). **Maria, ancient beds of basaltic lava, originated when asteroids punctured the lunar surface, letting magma bleed out.** Apparently the craters were flooded with layer upon layer of very fluid basaltic lava somewhat resembling the Columbia Plateau in the northwestern United States. The lava flows are often over 30 meters thick. The total thickness of the material that fills the maria could reach thousands of meters.

Long channels called [**rilles**](javascript:openGlossaryWnd('e_ga_06_rille')) are associated with maria. Rilles look somewhat similar to valleys or trenches. Rilles may be the remnants of ancient lava flows.

**Regolith**

All lunar terrains are mantled with a layer of gray debris derived from a few billion years of bombardment from meteorites. This soil-like layer, called [**lunar regolith**](javascript:openGlossaryWnd('e_ga_06_lunaregolith')), is composed of igneous rocks, glass beads, and fine lunar dust. In the maria that have been explored by *Apollo* astronauts, the lunar regolith is just over 3 meters thick.

**Lunar History**

The moon is our nearest planetary neighbor. Although astronauts have walked on its surface, much is still unknown about its origin. **The most widely accepted model for the origin of the moon is that when the solar system was forming, a body the size of Mars impacted Earth.** The impact, shown in Figure 21, would have liquefied Earth’s surface and ejected huge quantities of crustal and mantle rock from an infant Earth. A portion of this ejected debris would have entered an orbit around Earth where it combined to form the moon.

**Figure 21** *The moon may have formed when a large object collided with Earth. The resulting debris was ejected into space. The debris began orbiting around Earth and eventually united to form the moon.*

The giant-impact hypothesis is consistent with other facts known about the moon. The ejected material would have been mostly iron-poor mantle and crustal rocks. These would account for the lack of a sizable iron core on the moon. The ejected material would have remained in orbit long enough to have lost the water that the moon lacks. Despite this supporting evidence, some questions remain unanswered.

Geologists have worked out the basic details of the moon’s later history. One of their methods is to observe variations in crater density (the number of craters per unit area). The greater the crater density, the older the surface must be. From such evidence, scientists concluded that the moon evolved in three phases—the original crust (highlands), maria basins, and rayed craters.

During its early history, the moon was continually impacted as it swept up debris. This continuous attack, combined with radioactive decay, generated enough heat to melt the moon’s outer shell and possibly the interior as well. Remnants of this original crust occupy the densely cratered highlands. These highlands have been estimated to be as much as 4.5 billion years old, about the same age as Earth.

One important event in the moon’s evolution was the formation of maria basins. Radiometric dating of the maria basalts puts their age between 3.2 billion and 3.8 billion years, about a billion years younger than the initial crust. In places, the lava flows overlap the highlands, which also explains the younger age of the maria deposits.

The last prominent features to form were the rayed craters. Material ejected from these young depressions is clearly seen covering the surface of the maria and many older rayless craters. Even a relatively young crater like Copernicus, shown in Figure 22,must be millions of years old. If it had formed on Earth, erosional forces would have erased it long ago. If photographs of the moon taken several hundreds of millions of years ago were available, they would show that the moon has changed little. The moon is an inactive body wandering through space and time.

**Figure 22** *Rayed craters such as Copernicus were the last major features to form on the moon.*

**SECTION 22.3 Assessment Earth’s Moon**

**Reviewing Concepts**

(1)How do craters form?

(2)How did maria originate?

(3)What are the stages that formed the moon.

**Critical Thinking**

(4) **Identifying** On Earth, the four major spheres (atmosphere, hydrosphere, solid Earth, and biosphere) interact as a system. Which of these spheres are absent, or nearly absent, on the moon? Based on your answer, identify at least five processes that operate on Earth but not on the moon.

(5) **Inferring** Why are craters more common on the moon than on Earth, even though the moon is a much smaller target?

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